

What is claimed is:

1. Glass collectively comprising at least 70 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) REO, or (c) at least one of ZrO₂ or HfO₂, and containing not more than 30 percent by weight collectively As₂O₃, B₂O₃, GeO₂, P₂O₅, SiO₂, TeO₂, and V₂O₅, with the proviso that the glass does not comprise 35.73 percent by weight Al₂O₃, 42.17 percent by weight La₂O₃, 17.1 percent by weight ZrO₂, and 5 percent by weight of one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.

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2. The glass according to claim 1, wherein if Al₂O₃, REO, and at least one of ZrO₂ or HfO₂ are present, the glass comprises either not greater than 4 or at least 6 percent by weight of the at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.

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3. The glass according to claim 1, wherein if Al₂O₃, REO, and at least one of ZrO₂ or HfO₂ are present, the glass comprises at least 6 percent by weight of the at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.

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4. The glass according to claim 3 collectively comprising at least 75 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) REO, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass.

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5. The glass according to claim 3 collectively comprising at least 80 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) REO, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass.

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6. The glass according to claim 3 collectively comprising at least 85 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) REO, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass.

7. The glass according to claim 3 collectively comprising at least 90 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) REO, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass.

5 8. The glass according to claim 3 collectively comprising at least 99 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) REO, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass.

10 9. The glass according to claim 3 collectively comprising 100 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) REO, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass.

15 10. The glass according to claim 3 collectively comprising at least 70 percent by weight of Al₂O₃, REO, and at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.

20 11. The glass according to claim 3, wherein the at least one of Nb₂O₅ or Ta₂O₅ is present in an amount of at least 10 percent by weight, based on the total weight of the glass.

12. The glass according to claim 3 collectively comprising at least 70 percent by weight of REO, at least one of ZrO₂ or HfO₂, and at least one of Nb₂O₅ or Ta₂O₅.

25 13. The glass according to claim 12, wherein the at least one of Nb₂O₅ or Ta₂O₅ is present in an amount greater than 5 percent by weight, based on the total weight of the glass.

30 14. The glass according to claim 12, wherein the at least one of Nb₂O₅ or Ta₂O₅ is present in an amount of at least 10 percent by weight, based on the total weight of the glass.

15. The glass according to claim 3 comprising greater than 5 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass.

5 16. The glass according to claim 3 comprising at least 10 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass.

17. The glass according to claim 3 comprising at least 15 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass.

10 18. The glass according to claim 3 comprising at least 20 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass.

19. The glass according to claim 3 comprising at least 25 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass.

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20. The glass according to claim 3 comprising the at least one of Nb_2O_5 or Ta_2O_5 , in a range from 10 to 40 percent by weight, based on the total weight of the glass.

20 21. The glass according to claim 3 collectively comprising at least 70 percent by weight of Al_2O_3 , REO, at least one of ZrO_2 or HfO_2 , and at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass.

22. The glass according to claim 21, wherein the at least one of ZrO_2 or HfO_2 is present in an amount of at least 5 percent by weight, based on the total weight of the glass.

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23. The glass according to claim 21, wherein the at least one of ZrO_2 or HfO_2 is present in an amount of at least 10 percent by weight, based on the total weight of the glass.

30 24. Ceramic comprising the glass according to claim 3.

25. A method for making the glass according to claim 3, the method comprising:

melting sources of (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) REO, or (c) at least one of ZrO_2 or HfO_2 to provide a melt; and
5 cooling the melt to provide the glass.

26. A method for making ceramic comprising glass according to claim 3, the method comprising:

melting sources of (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of
10 (a) Al_2O_3 , (b) REO, or (c) at least one of ZrO_2 or HfO_2 to provide a melt; and
cooling the melt to provide the ceramic.

27. A method for making an article comprising glass according to claim 3, the method comprising:

15 providing glass powder comprising glass, the glass collectively comprising at least 70 percent by weight of (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) REO, or (c) at least one of ZrO_2 or HfO_2 , and containing not more than 30 percent by weight collectively As_2O_3 , B_2O_3 , GeO_2 , P_2O_5 , SiO_2 , TeO_2 , and V_2O_5 , with the proviso that the glass does not comprise 35.73 percent by weight Al_2O_3 , 42.17 percent by
20 weight La_2O_3 , 17.1 percent by weight ZrO_2 , and 5 percent by weight of one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass, the glass having a T_g ; and
heating the glass powder above the T_g such that the glass beads coalesce to form a shape and provide the article.

25 28. An optical waveguide comprising:
a substrate; and
a glass according to claim 3 on a surface of the substrate.

29. The optical waveguide according to claim 28, wherein the glass is doped
30 with a rare earth dopant.

30. The optical waveguide according to claim 28 wherein the rare earth dopant is selected from the group consisting of cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, or their other compounds and mixtures thereof.

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31. An optical waveguide comprising a glass fiber having a core material and a cladding surrounding the core material, wherein the core material comprises a glass according to claim 3.

10 32. The optical waveguide according to claim 31, wherein the glass is doped with a rare earth dopant.

33. The optical waveguide according to claim 29, wherein the rare earth dopant is selected from the group consisting of cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, or their other compounds, and mixtures thereof.

15 34. An optical amplifier comprising:
an optical pump source which provides optical pump light; and
20 an optical waveguide coupled to receive the optical pump light from the optical pump source, wherein the optical waveguide comprises a glass according to claim 3.

25 35. The optical amplifier according to claim 34, wherein the glass is doped with a rare earth dopant.

36. The optical amplifier according to claim 35, wherein the rare earth dopant is selected from the group consisting of cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, or their other compounds, and mixtures thereof.

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37. A method for amplifying optical signals, the method comprising:
inputting the optical signals to an optical waveguide comprising a glass
according to claim 3; and
applying pump light to the optical waveguide to cause the waveguide to
5 provide optical gain to the optical input signals.

38. The method according to claim 37, wherein the glass is doped with a rare
earth dopant.

10 39. Ceramic comprising at least 75 percent by volume glass, the glass
collectively comprising at least 70 percent by weight of (i) at least one of Nb_2O_5 or Ta_2O_5
and (ii) at least two of (a) Al_2O_3 , (b) REO, or (c) at least one of ZrO_2 or HfO_2 , and
containing not more than 30 percent by weight collectively As_2O_3 , B_2O_3 , GeO_2 , P_2O_5 ,
 SiO_2 , TeO_2 , and V_2O_5 , with the proviso that the glass does not comprise 35.73 percent by
15 weight Al_2O_3 , 42.17 percent by weight La_2O_3 , 17.1 percent by weight ZrO_2 , and 5 percent
by weight of one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass.

40. The ceramic according to claim 39, wherein if Al_2O_3 , REO, and at least one
of ZrO_2 or HfO_2 are present, the glass comprises either not greater than 4 or at least 6
20 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the
glass.

41. The ceramic according to claim 39, wherein if Al_2O_3 , REO, and at least one
of ZrO_2 or HfO_2 are present, the glass comprises at least 6 percent by weight of the at least
25 one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass.

42. Glass-ceramic collectively comprising at least 70 percent by weight of (i) at
least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) REO, or (c) at least one
of ZrO_2 or HfO_2 , and containing not more than 30 percent by weight collectively As_2O_3 ,
30 B_2O_3 , GeO_2 , P_2O_5 , SiO_2 , TeO_2 , and V_2O_5 .

43. The glass-ceramic according to claim 42, wherein if Al_2O_3 , REO, and at least one of ZrO_2 or HfO_2 are present, the glass-ceramic comprises either not greater than 4 or at least 6 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass-ceramic.

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44. The glass-ceramic according to claim 42, wherein if Al_2O_3 , REO, and at least one of ZrO_2 or HfO_2 are present, the glass-ceramic comprises at least 6 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass-ceramic.

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45. The glass-ceramic according to claim 41 collectively comprising at least 75 percent by weight of (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) REO, or (c) at least one of ZrO_2 or HfO_2 , based on the total weight of the glass-ceramic.

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46. The glass-ceramic according to claim 42 collectively comprising at least 80 percent by weight of (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) REO, or (c) at least one of ZrO_2 or HfO_2 , based on the total weight of the glass-ceramic.

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47. The glass-ceramic according to claim 42 collectively comprising at least 85 percent by weight (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) REO, or (c) at least one of ZrO_2 or HfO_2 , based on the total weight of the glass-ceramic.

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48. The glass-ceramic according to claim 42 collectively comprising at least 90 percent by weight of (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) REO, or (c) at least one of ZrO_2 or HfO_2 , based on the total weight of the glass-ceramic.

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49. The glass-ceramic according to claim 42 collectively comprising at least 95 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) REO, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass-ceramic.

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50. The glass-ceramic according to claim 42 collectively comprising at least 99 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) REO, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass-ceramic.

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51. The glass-ceramic according to claim 42 collectively comprising 100 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) REO, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass-ceramic.

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52. The glass-ceramic according to claim 42 collectively comprising at least 70 percent by weight of Al₂O₃, REO, and at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass-ceramic.

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53. The glass-ceramic according to claim 52, wherein the at least one of Nb₂O₅ or Ta₂O₅ is present in an amount of at least 10 percent by weight, based on the total weight of the glass-ceramic.

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54. The glass-ceramic according to claim 52 collectively comprising at least 70 percent by weight of REO, at least one of ZrO₂ or HfO₂, and at least one of Nb₂O₅ or Ta₂O₅.

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55. The glass-ceramic according to claim 54, wherein the at least one of Nb₂O₅ or Ta₂O₅ is present in an amount greater than 5 percent by weight, based on the total weight of the glass-ceramic.

56. The glass-ceramic according to claim 54, wherein the at least one of Nb_2O_5 or Ta_2O_5 is present in an amount of at least 10 percent by weight, based on the total weight of the glass-ceramic.

5 57. The glass-ceramic according to claim 42 collectively comprising at least 70 percent by weight of Al_2O_3 , REO, at least one of ZrO_2 or HfO_2 , and at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass-ceramic.

10 58. The glass-ceramic according to claim 57, wherein the at least one of ZrO_2 or HfO_2 is present in an amount of at least 5 percent by weight, based on the total weight of the glass-ceramic.

15 59. The glass-ceramic according to claim 57, wherein the at least one of ZrO_2 or HfO_2 is present in an amount of at least 10 percent by weight, based on the total weight of the glass-ceramic.

20 60. The glass-ceramic according to claim 42, with the proviso that the glass-ceramic does not comprise 35.73 percent by weight Al_2O_3 , 42.17 percent by weight La_2O_3 , 17.1 percent by weight ZrO_2 , and 5 percent by weight of one of Nb_2O_5 or Ta_2O_5 based on the total weight of the glass-ceramic.

61. A method for making glass-ceramic according to claim 42, the method comprising:
heat-treating glass to convert at least a portion of the glass to crystalline
25 ceramic and provide the glass-ceramic, the glass collectively comprising at least 70 percent by weight of (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) REO, or (c) at least one of ZrO_2 or HfO_2 , and containing not more than 30 percent by weight collectively As_2O_3 , B_2O_3 , GeO_2 , P_2O_5 , SiO_2 , TeO_2 , and V_2O_5 , based on the total weight of the glass.

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62. The method according to claim 61, with the proviso that the glass does not comprise 35.73 percent by weight Al_2O_3 , 42.17 percent by weight La_2O_3 , 17.1 percent by weight ZrO_2 , and 5 percent by weight of one of Nb_2O_5 or Ta_2O_5 based on the total weight of the glass.

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63. A method for making glass-ceramic according to claim 42, the method comprising:

heat-treating ceramic comprising glass to convert at least a portion of the glass to crystalline ceramic to provide the glass-ceramic, the glass collectively comprising at least 70 percent by weight of (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) REO, or (c) at least one of ZrO_2 or HfO_2 , and containing not more than 30 percent by weight collectively As_2O_3 , B_2O_3 , GeO_2 , P_2O_5 , SiO_2 , TeO_2 , and V_2O_5 , based on the total weight of the glass.

64. The method according to claim 63, with the proviso that the glass does not comprise 35.73 percent by weight Al_2O_3 , 42.17 percent by weight La_2O_3 , 17.1 percent by weight ZrO_2 , and 5 percent by weight of one of Nb_2O_5 or Ta_2O_5 based on the total weight of the glass.

65. A method for making a glass-ceramic article, the method comprising:
providing glass powder, the glass collectively comprising at least 70 percent by weight of (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) REO, or (c) at least one of ZrO_2 or HfO_2 , and containing not more than 30 percent by weight collectively As_2O_3 , B_2O_3 , GeO_2 , P_2O_5 , SiO_2 , TeO_2 , and V_2O_5 , based on the total weight of the glass, the glass having a T_g ; and

heating the glass powder above the T_g such that the glass powder coalesces to form a shape and provide a glass article; and

heat-treating the glass article to convert at least a portion of the glass to crystalline ceramic to provide the glass-ceramic article.

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66. The method according to claim 65, with the proviso that the glass does not comprise 35.73 percent by weight Al_2O_3 , 42.17 percent by weight La_2O_3 , 17.1 percent by weight ZrO_2 , and 5 percent by weight of one of Nb_2O_5 or Ta_2O_5 based on the total weight of the glass.

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67. The method according to claim 66, wherein if Al_2O_3 , REO, and at least one of ZrO_2 or HfO_2 are present, the glass comprises either not greater than 4 or at least 6 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass.

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68. The method according to claim 66, wherein if Al_2O_3 , REO, and at least one of ZrO_2 or HfO_2 are present, the glass comprises at least 6 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass.

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